# NREL's Hybrid Power Test Bed

**by Gerry Nix 12/99**

## Background

In a remote Alaskan village, wind turbines and backup diesel generators provide electricity for lighting, heating, and hot water on a short winter day. This is one of many hybrid power systems researchers can simulate at the National Renewable Energy Laboratory's (NREL's) Hybrid Power Test Bed (HPTB) at the National Wind Technology Center (NWTC).

Hybrid power systems combine multiple power sources such as wind turbines, photovoltaics (PV) arrays, diesel generators, and battery storage systems. They typically are used in remote areas where major electric grids do not exist.

## Scope

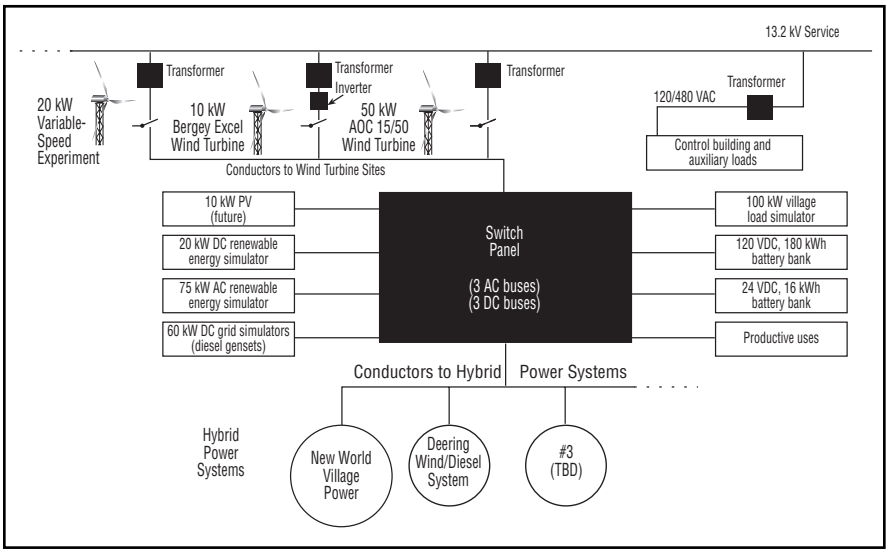
The HPTB is the U.S. industry's laboratory to develop and test components, control systems, and integrated hybrid power generation systems. Using simulated village loads, researchers can evaluate the interaction of hybrid power systems under realistic conditions. Design engineers are able to work through actual problems the system might encounter in the field.

The test bed allows engineers to evaluate system performance, cost-effectiveness, and reliability using real or simulated solar and winds energy resources. Simulated energy resources allow designers to repeat experiments as they improve system designs. This feature is important for developing new components, advanced hybrid systems, and dispatch-and-control systems.

U.S. companies can use the HPTB to train customers from other countries. By providing technical assistance to potential users, the NWTC encourages the growth of international markets for the U.S. wind industry.

## Test Bed Capabilities and Features

Engineers can evaluate the moment-by-moment dynamics of hybrid power system operation, gather data on long-term performance, or demonstrate innovative design concepts with the HPTB. High-speed data acquisition equipment monitors power quality, harmonic distortion, and electrical transients. A village load simulator with resistive and inductive elements can create power factors down to 0.5, allowing test engineers to evaluate system operation under severe conditions that




*Components of NREL's Hybrid Power Test Bed.*

may be encountered in real operations. Engineers can also investigate the power system's dynamic response to sudden load changes and to conditions of phase imbalance or loss of phase.

Test bed engineers can evaluate the long-term performance of a hybrid power system, including its energy delivery (in kilowatt-hours), and diesel fuel consumption. They can monitor wind speed, solar insolation, and the performance of battery energy storage. They can characterize system performance under a range of operating conditions, and evaluate alarms, emergency shutdown procedures, and other critical functions.

The research test bed provides a minimal risk environment for developing, testing, and evaluating new concepts when compared to proving them in the field at remote locations. New power conversion devices, emerging energy storage technologies, prototype control systems, and innovative system architectures are examples of concepts that can be evaluated using the HPTB.

The HPTB has a number of unique features. These features include the ability to test up to three hybrid power systems simultaneously, use either real or simulated renewable energy sources, simulate a local electric grid, test with real or simulated village loads, and test wind turbine systems producing direct or alternating current (DC or AC).

A custom-designed switch panel with three AC and three DC buses gives the test bed the flexibility to quickly connect or disconnect various system components for tailored testing programs. The switch panel can connect selected components with combined capacities of up to 100 kilowatts (kW) onto common power buses. Engineers can rapidly change testing configurations by opening and closing a few switches.

Simulated renewable energy sources allow engineers to conduct repeatable testing. An induction generator functions as a 75-kW AC source simulator. A planned DC source simulator that will function as a solid-state device may provide up to 20 kW of reproducible DC power.

Multiple diesel generator sets are available for use in hybrid systems under test. They may also serve as grid simulators, allowing researchers to test a hybrid power system's ability to synchronize its power modules and connect with an existing small grid.

Renewable energy technologies at the facility include various wind turbines, rated from 1.5 to 100 kW. A PV array rated at 10 kW is also planned.

The NWTC's solar and wind resources allow a full range of power-system testing under normal operating conditions.

The test bed incorporates various village load simulators. The computer-controlled simulators mimic typical electric loads for a small village. The test bed also has the flexibility to incorporate real village loads such as power tools, lighting systems, water pumps, or icemakers into its evaluations. The HPTB includes a PC-based control and data acquisition system with a graphical interface in LabVIEW. Hybrid Power Test Bed equipment includes:

| **Component** | **Rating** |
|---|---|
| Wind turbines | 1.5 to 100 kW AC, to 10 kW DC |
| Diesel gensets | 125, 80, 40, 40 kW |
| AC renewable energy simulator | 75 kW |
| DC battery banks | 24,120 and 228 volts |
| Village load simulators | To 120 kW, inductive and resistive |

## Current Testing

The HPTB is fully operational with current projects to:

- Test inverters (Trace and Advanced Energy Systems)
- Develop and test a control and energy storage system for a high-penetration wind-hybrid project for installation at Wales, Alaska
- Characterize a Northern Power Systems Village Power 50-kW power system module.

Another project will seek to characterize the performance of the Northern Power Systems' 100-kW cold-weather turbine for hybrid applications.

The HPTB is available for use by industry.

## NREL Contact

Web site: *http://www.rsvp.nrel.gov*

Gerry Nix
NREL/National Wind Technology Center
phone: 303-384-6925
fax: 303-384-6901
e-mail: gerald_nix@nrel.gov

Produced by the National Renewable Energy Laboratory, a U.S. Department of Energy national laboratory.

Printed with renewable source ink on paper containing at least 50% wastepaper, including 20% postconsumer waste.

NREL/FS-500-27731